Mutualistic Microbes and Development of Mucosal Defense in the Mammalian Intestine

H. R. Gaskins

Departments of Animal Sciences and Pathobiology, Division of Nutritional Sciences, Institute for Genomic Biology, University of Illinois, Urbana, Illinois 61801

All major groups of microbes are represented in the gastrointestinal microbiota of mammals although bacteria predominate. Importantly, bacterial cells outnumber animal (host) cells by a factor of ten and have a profound influence on immunological, nutritional, physiological and protective processes in the host animal.

The intestinal microbiota of the pig, and mammals in general, is viewed typically as being beneficial for the host. Indigenous bacteria provide the host with nutrients, including short-chain fatty acids, vitamin K, B vitamins, and amino acids. Intestinal bacteria also prevent colonization by pathogenic organisms by competing more successfully for nutrients or for epithelial attachment sites. Further, the production by intestinal bacteria of antimicrobial compounds, volatile fatty acids, and chemically modified bile acids, creates a local environment that is generally unfavorable for the growth of enteric pathogens. While it is certain that mutualistic bacteria provide both nutritional and defensive functions to the host animal, it is also clear that the host invests substantially in defensive efforts to first sequester intestinal microbes away from the epithelial surface (pathogens and nonpathogens alike), and second to quickly mount inflammatory and immune responses against organisms that manage to breech epithelial defenses.

This mutualistic relationship has been selected over evolutionary time resulting in a stable microbiota in mature animals that is generally similar in composition and function in a diverse range of animal species. Despite evolutionary stability, the intestinal microbiota develops in individual animals in a characteristic successional pattern that requires substantial adaptation by the host during early life periods. The impact of the developing microbiota as well as the metabolic activities of climax communities require especial consideration when viewed in the context of animal production in which efficiency of growth is a primary objective.

Much of our knowledge regarding the contributions of intestinal bacteria to the development and functions of the mucosal immune system is derived from studies with germfree (GF) animals. These data illustrate the protective nature of mutualistic bacteria, as well as their role in the development of the mucosal immune system of the host. A brief review will be given of 1) the structure and function of mucosal defense mechanisms, 2) studies with GF animals, which support the concept that the mucosal immune system evolved largely in response to the normal microbiota, and 3) the concept of an optimal intestinal microbiota in terms of animal health versus growth performance.

Email: hgaskins@uiuc.edu